

--previous scheduling--.

At line 29, after "scheduling", insert --methods--;

after "system", insert --of the invention--.

At line 33, after "operation,", insert --and--.

REMARKS

Claims 1-18 were filed and are pending. Claims 1-18 were rejected under 35 U.S.C. § 103. Claims 3, 6 and 12 have been amended. Claims 19 and 20 have been added. Reconsideration and allowance of Claims 1-18, and allowance of Claims 19 and 20 is requested.

Rejection of Claims under 35 U.S.C. § 103

The Examiner rejected Claims 1-18 under 35 U.S.C. § 103 as unpatentable over Syswerda in view of Tanaka. Applicants thank the Examiner for his readily apparent careful consideration of the instant application (for example, Applicants note that the Examiner has provided detailed reasons for his rejections of each claim of the present application). However, as explained below, Applicants contend that each of Claims 1-18 are patentable over Syswerda in view of Tanaka.

The Examiner stated:

Regarding claim 1, Syswerda teaches of a method for scheduling an activity (See Syswerda, Abstract) that uses consumable resources (See Syswerda; column 4, lines 12-19) and is governed by a set of predefined constraints (See Syswerda; abstract; column 1 line 68 through column 2, line 4).

Applicants' contend that, contrary to the Examiner's

assertion, Syswerda does not teach a method for scheduling an activity that uses consumable resources, but, rather, teaches a method that schedules tasks that use reusable resources only. For example, in discussing a model scheduling problem used to test the method taught therein, Syswerda states at column 4, lines 26-28 that "[t]here was only a single instance of each resource so that a conflict for any resource was considered a hard constraint violation." However, though there was only a single instance of each resource, each resource could be used by multiple tasks during a schedule, albeit at different times (see, e.g., FIG. 1B of Syswerda). This can only happen if the resources are reusable, rather than consumable; therefore, Syswerda teaches a method for scheduling the use of reusable resources. Consequently, there is no teaching in Syswerda of how to modify a schedule to accommodate overusage of a consumable resource. Syswerda does not teach, for example, modifying a schedule to replenish a consumable resource when the amount of the consumable resource has either been completely depleted or has fallen below a specified magnitude, as can be accomplished by the method of Claim 1.

Further, there is also no indication in Tanaka that the scheduling system taught therein can schedule an activity that uses consumable resources. In the particular example of a scheduling problem discussed in Tanaka, the constraints relate to machines (constraints C_1 and C_2) and to the power consumption of an entire factory at a given time (constraint C_3). Each of these resources are reusable

resources.

Claim 1 (as amended), on the other hand, recites "[a] method for scheduling a complex activity that is governed by a set of pre-defined constraints including consumable resource constraints" (emphasis added). As stated at page 38, line 33 to page 39, line 6 of Applicants' specification:

The system and method according to the invention also enable repair of consumable resource constraints. This has not previously been possible in systems that use iterative repair for scheduling. Unlike repairs to reusable resource constraint violations, repairs to consumable resource constraint violations cannot always be achieved by moving one or more tasks. In some cases, a new task or tasks must be added to the schedule to produce more of the consumable resource.

The repair of consumable resource constraint violations in accordance with Applicants' invention is described in detail in Applicants' specification at page 39, line 6 to page 42, line 12.

As indicated above, neither Syswerda nor Tanaka teach or suggest, either alone or in combination, a method for scheduling an activity in which the activity is "governed by a set of pre-defined constraints including consumable resource constraints," as recited in Claim 1. Rather, Syswerda and Tanaka both teach methods and/or systems for scheduling an activity in which only reusable resources are used (i.e., solving a scheduling problem in which only reusable resource constraints are present). The polynomial complexity of this type of problem addressed by Syswerda and Tanaka is known to be NP complete (see, e.g., column 1, lines 15-18 of Syswerda). The addition of consumable resource constraints - as in the

method of Claim 1 - to a scheduling problem increases the complexity of the problem (since it may be necessary to add new variables, e.g., new tasks, to the scheduling problem), creating a new type of problem known as a "synthetic planning problem." Synthetic planning problems are within the class of problems known to be P-space complete. As known to those skilled in this art, P-space complete problems are provably more difficult to solve than NP complete problems. In short, then, Syswerda and Tanaka teach methods and/or systems for solving scheduling problems that can be - and typically are - significantly simpler than the planning problems which can be solved by the method of Claim 1.

Further, as stated in Applicants' specification at page 11, lines 3-5 (as amended), "[t]he system and method according to the invention can resolve consumable resource (inventory) constraints and reusable resource (capacity) constraints simultaneously." This aspect of Applicants' invention is captured in newly added Claim 19. As stated in Applicants' specification at page 13, lines 21-24, "[t]he system and method according to the invention are particularly useful in any situation where it is desired to schedule an activity subject to both consumable and reusable resource constraints." This capability of Applicants' invention has not been possible with previous scheduling methods (see Applicants' specification at, for example, page 3, lines 25-32; page 8, lines 4-17; and page 11, lines 15-20).

The Examiner further stated with respect to Claim 1:

Syswerda does not teach of repairing constraint violations. All hard constraints are strictly met to generate legal schedules. The evaluation of the soft constraints and whether they are violated along with their associated weights are used to establish scores for each schedule.

Tanaka teaches of selectively relaxing violated constraints in order to generate a legal schedule (See Tanaka, abstract). The examiner respectively asserts that constraint relaxation is one method of constraint violation repair which would fall within the boundaries of the claims as presently drafted.

The motivation to modify the teachings of the primary reference, Syswerda, with that of the secondary reference, Tanaka, comes directly from the secondary reference.

Claim 1 (as amended) recites "[a] method for scheduling a complex activity that is governed by a set of pre-defined constraints including consumable resource constraints, ... comprising the [step] of ... repairing one or more constraint violations of [a] current schedule by modifying the current schedule" (emphasis added). Applicants agree with the Examiner that Syswerda does not teach repairing constraint violations, as is recited in Claim 1. However, Applicants disagree with the Examiner that the constraint relaxation taught by Tanaka is the same as the constraint violation repair performed in the method of Claim 1.

Tanaka states at column 1, lines 32-34, in discussing constraint relaxation, that "constraints can be relaxed to widen a 'solution space' or 'a set of candidate solutions'." Thus, constraint relaxation "solves" a scheduling problem by redefining the problem so that it is easier to solve. In contrast, constraint repair generally does not widen a solution

space or a set of candidate solutions. In other words, unlike constraint relaxation, constraint repair generally does not change the problem to make it easier to solve. (In fact, a constraint repair method is often prohibited from doing so.) Instead, constraint repair can - and typically does - use a repair method to repair constraint violations within the same solution space or set of candidate solutions, i.e., within a solution space defined by the same set of constraints. A method for accomplishing constraint repair is discussed in detail in Applicants' specification with respect to FIG. 5. As stated in Applicants' specification at page 35, lines 11-13, "[r]epairing a constraint violation typically involves moving to different times one or more tasks that cause the constraint violation;" however, constraint repairs can be accomplished in other ways (e.g., by exploding a routing option to add tasks to a schedule), as discussed elsewhere in Applicants' specification. In any event, constraint repair does not necessitate (and frequently prohibits) relaxation of a constraint, as is taught by Tanaka. Thus, whether or not there is a motivation to modify the teaching of Syswerda with the teaching of constraint relaxation of Tanaka, such modification still does not teach or suggest a method as recited in Claim 1, since the constraint relaxation taught by Tanaka is not the same as the constraint repair recited in Claim 1. The constraint relaxation described by Tanaka is more closely akin to (though not the same as) adjustment of a weight associated with a constraint, as can be done in accordance with

Applicants' invention to prescribe the "hardness" or "softness" of a constraint (as described, for example, in Applicants' specification at page 50, line 21 to page 51, line 3).

In view of the foregoing, Applicants submit that Claim 1 is allowable over the combination of Syswerda and Tanaka. Further, since Claims 2-11 are dependent claims each having Claim 1 as base claim, Claims 2-11 are each allowable over the combination of Syswerda and Tanaka for at least the reasons given above with respect to Claim 1. Applicants therefore request withdrawal of the rejections under 35 U.S.C. § 103 of Claims 1-11.

Similar to Claim 1, Claim 12 recites "[a] system for scheduling a complex activity that is governed by a set of pre-defined constraints including consumable resource constraints . . . , comprising: . . . a processing device . . . [that] is capable of repairing one or more constraint violations for each schedule by modifying the schedule." Thus, Claim 12 is allowable over the combination of Syswerda and Tanaka for at least the reasons given with respect to Claim 1. Further, since Claims 13-18 are dependent claims each having Claim 12 as base claim, Claims 13-18 are each allowable over the combination of Syswerda and Tanaka for at least the reasons given with respect to Claim 12 (i.e., for the reasons given above with respect to Claim 1). Applicants therefore request withdrawal of the rejections under 35 U.S.C. § 103 of Claims 12-18.

New Claims

Claims 19 and 20 have been added.

Claim 19 depends from Claim 1 and recites that "the set of pre-defined constraints further includes reusable resource constraints." As mentioned above, the capability to schedule an activity subject to both consumable and reusable resource constraints by simultaneously resolving both of those types of constraints is an advantageous aspect of the scheduling method of Claim 19 that has not been possible with previous scheduling methods. Support in Applicants' specification for Claim 19 is discussed in more detail above.

Similar to Claim 1, Claim 20 recites "[a] computer readable medium encoded with one or more computer programs for enabling scheduling of a complex activity that is governed by a set of pre-defined constraints including consumable resource constraints, comprising: ... instructions for repairing one or more constraint violations of [a] current schedule by modifying the current schedule" Thus, Claim 20 is allowable for at least the reasons given above with respect to Claim 1. Claim 20 is supported in Applicants' specification by, for example, the description at page 16, line 29 to page 17, line 9.

CONCLUSION

Claims 1-18 were pending. Claims 1-18 were rejected. Claims 3, 6 and 12 have been amended. Claims 19 and 20 have been added. In view of the foregoing amendments and remarks,

it is requested that Claims 1-20 be allowed. If the Examiner wishes to discuss any aspect of this application, the Examiner is invited to telephone Applicants' undersigned attorney at (408) 945-9912.

Respectfully submitted,

David R. Graham
David R. Graham
Registration No. 36,150
Attorney for Applicants

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231, on January 17, 1997.

Date: 1-17-97 David R. Graham
Attorney for Applicants